Volume 18 September, 1953 Number 3

CASTANEA

The Journal of the Southern Appalachian Botanical Club

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PUBLISHED FOR THE CLUB
MARCH, JUNE, SEPTEMBER, DECEMBER
at
West Virginia University
Morgantown, W. Va.

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CASTANEA

The Journal
of the
Southern Appalachian Botanical Club

Volume 18 September, 1953 Number 3

Shading Effects of Natural Canopies on Holly Characteristics[1]

E. H. Tryon and R. W. Pease

INTRODUCTION

Experimental marketing of natural sprays from American holly (*Ilex opaca* Ait.) growing wild was undertaken in 1944 by the West Virginia Agricultural Experiment Station. The importance of marketing high quality material was demonstrated at once. As a result, research was undertaken to find methods for increasing the production of quality sprays.

Hollies which grow rapidly and have large crowns with many attractive leaves and an abundance of bright red berries are desirable. This study, however, is limited to an examination of the effects of shade from a natural canopy[2] of trees and shrubs upon rate of height growth, size of crown, number of leaves, and leaf quality.[3]

The amount of shade, as found under canopies of different densities, is not considered to be the only cause of the differences in holly characteristics reported here. Changes in canopy density affect such factors as soil moisture, soil nutrients, air temperature humidity, and wind velocity. These factors may be as important as shade itself in the resultant effects on the holly. However, only shade, expressed as percentage of sunlight, was measured because it takes into consideration the combined effects of these other factors on holly characteristics.

[1]Published with the approval of the Director, West Virginia Agricultural Experiment Station, as Scientific Paper No. 471.

[2]Canopy refers to the crowns of the trees and bushes overtopping the holly.

[3]The field work was financed largely by Sears-Roebuck Agricultural Foundation.

METHODS

A total of six ungrazed areas in Nicholas and Upshur counties having an abundance of hollies in open fields and in adjacent woods was selected for study. Each plot contained 42 hollies, 14 in the open and 28 under a canopy, giving a total of 252 trees on the six plots. Hollies were selected which were between two and six feet in height and each one given a permanent number. As current growth was observed for three years, a few of the hollies had reached a height of eight feet when the final growth data were taken. By then the total number of trees had been reduced to 228, due to injury or cutting.

The percentage of sunlight reaching each holly growing under a canopy was determined by measuring the number of foot-candles of sunlight reaching the crown of the tree and comparing that value with the number of foot-candles of sunlight in the open. These measurements were taken with a light meter of the photoelectric cell type. An attempt was made to take all light readings on bright days between 10:00 a.m. and 3:00 p.m. All readings were taken during the summer when the trees in the canopy were in full leaf.

The total height of each holly and the length and width of the crown were measured to the nearest tenth of a foot. The surface of a paraboloid was taken to represent the crown-surface of the holly trees. Consequently the area of the crown-surface was computed for each tree, using the formula for the surface area of a paraboloid which requires measurements of crown width and length. The number of leaves on each holly was also obtained. On hollies having few leaves the actual number was counted; on hollies having several hundreds of leaves an actual count was made of a portion of the crown, and the total carefully estimated from the number in that portion. The number of leaves, whether counted or estimated, was checked by at least one other person.

Length, lustre, and color of one-year-old leaves were also measured. Ten leaves were collected in a random manner from each tree. The length of each blade, exclusive of the petiole, was measured to the nearest tenth of an inch. The degree of lustre was determined by estimate, and the color of the leaves was determined by the use of a color chart.[4]

After all other field data had been taken, the age of each tree was determined by the number of rings in the base of each holly stem. The hollies were cut or sections were removed from the base of the stems so that the rings could be counted.

[4]Tryon, E. H. Color Comparisons of Leaves of Open and Shade Grown Holly. Castanea 14: 117-126. 1949.

The effects of shade from a canopy on the growth rate of the factors studied, in most phases, was summarized by first separating the data into three sunlight classes. These three classes were full sunlight (100% sunlight), medium shade (21% to 80% sunlight), and heavy shade (less than 21% sunlight). The number of individuals in each class was nearly equal. Then, by the method of least squares, curves were fitted for each class according to the factor being investigated.

Statistical tests were used to evaluate the differences between different portions of the curves. The magnitude of the differences between the curves was so large that preliminary tests were used.

In studying the effect of shade on height and on crown area, the points from which the curves were calculated were adjusted to similar age. The differences between the means, as read from the curves, then were tested by the *t*-test. In testing the effect of shade on number of leaves, the points on the curves were adjusted to similar crown areas, and the significance of the differences also determined by the *t*-test.

This preliminary testing showed such a high probability of the differences between the important relationships being real and not due to chance, that more sensitive statistical tests were deemed unnecessary.

RESULTS

Growth

Height, *crown area*, and *number of leaves* of hollies growing under canopies of different densities and in the open were studied to show quantitatively how shade from a canopy affects the amount of foliage material produced.

Height

The effect of shade from a canopy on the height growth of holly is shown in Figure 1. Curves of height over age for the three sunlight classes indicate how the amount of shade influences height growth.

Little difference in height of the youngest trees may be noticed between the three sunlight classes, but the difference increases with age. At 13 years and above, all differences between the curves are highly significant. At an age of 16 years, hollies grown in full sunlight average 7.3 feet in height. Those grown in medium shade are about one foot shorter, and those grown in heavy shade are two feet shorter. This indicates that the older hollies growing under canopies are reduced in height growth.

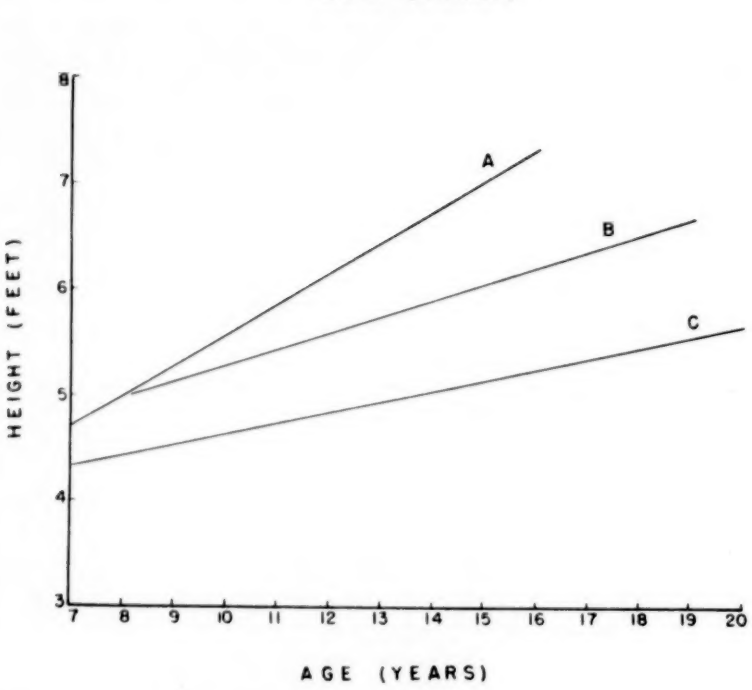

Figure 1. Total height of holly by sunlight classes and age.
A. Full sunlight (100% sunlight)
B. Medium shade (21%-80% sunlight)
C. Heavy shade (less than 21% sunlight)

Crown Area

The size of the crown of the hollies was studied because it is one of the factors which affects the amount of foliage produced. The curves of crown area, plotted over age for the three sunlight classes, are presented in Figure 2. The differences in crown areas between the three sunlight classes are small for the younger trees, but increase with age. They become highly significant at 11 years and older.

A 16-year-old holly, open grown, has an average crown area of 61.5 square feet, whereas, for the medium and heavy shade classes, the crown areas average 41.0 and 26.5 square feet, respectively. Thus the size of the crown of the older hollies growing under a canopy is reduced, and the more dense the canopy, the greater the reduction in the crown area.

Number of Leaves

The number of leaves has a significance when related to density of the crown, and this was studied by relating the number of leaves to crown area under different intensities of sunlight. The relationships are shown pictorially in Figure 3. This figure, constructed by the method of harmonized curves, has three dimensions and illustrates the way in which crown area and percentage of sunlight jointly affect the number of leaves.

The principal fact illustrated by the three dimensional graph is that for crown areas of the same size fewer leaves are produced under a canopy than in the open, and the more dense the canopy the fewer the leaves.

For statistical purposes, curves of number of leaves over crown areas for the three sunlight classes were compared, using the same

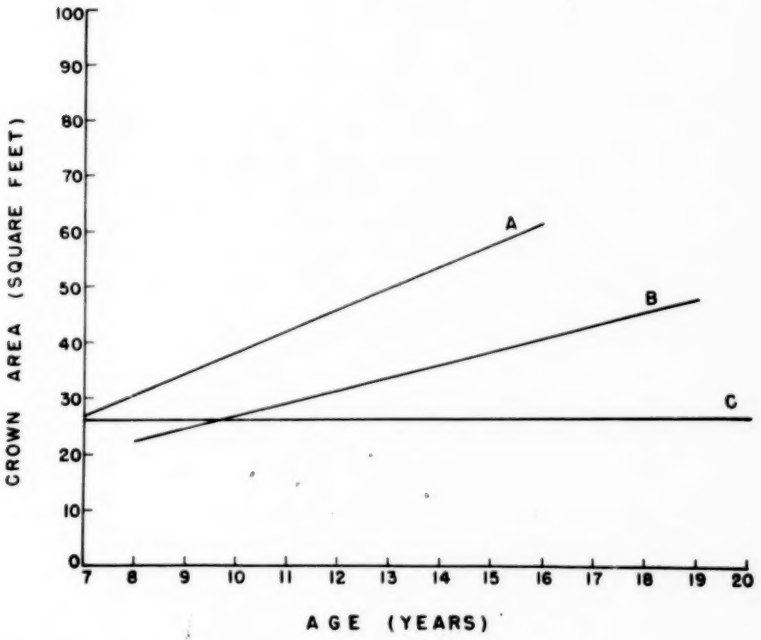

Figure 2. Crown area of holly by sunlight classes and age.

A. Full sunlight (100% sunlight)
B. Medium shade (21%-80% sunlight)
C. Heavy shade (less than 21% sunlight)

technique as that for studying the effect of shade on both height and crown area. Highly significant differences between the curves were obtained at crown areas of 40 square feet and above.

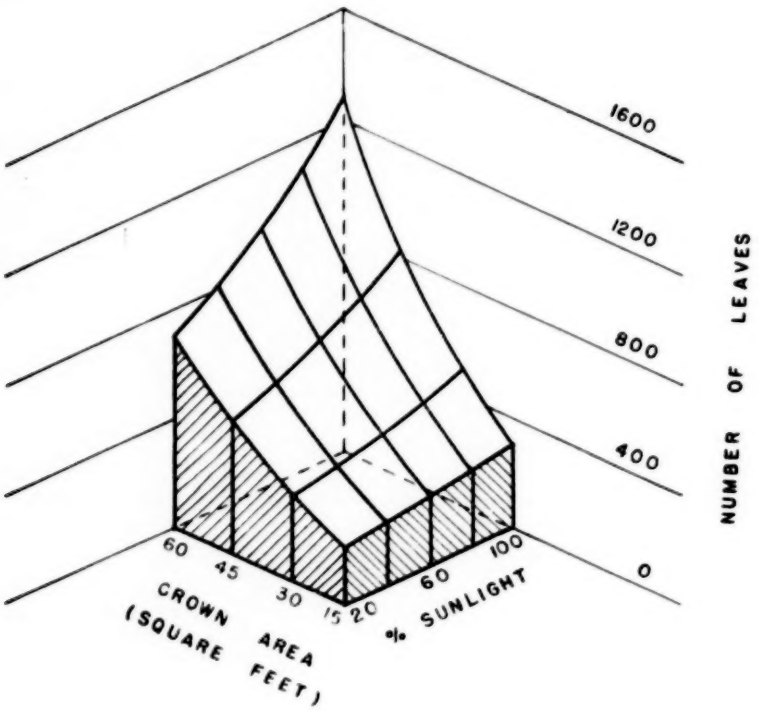

Figure 3. Number of leaves on holly trees as influenced by crown area and percentage of sunlight received under natural canopies.

Another method of illustrating the effect of shade from a canopy on number of leaves is illustrated by the three graphs in Figure 4. These three-dimensional graphs, also constructed by the method of harmonized curves picture conditions in the three sunlight classes. Each graph shows how crown area and age influence the number of leaves for that sunlight class. The comparison between the smaller graphs for the medium and heavy shade classes, and the larger graph for full sunlight, shows at a glance how shade from a canopy reduces the number of leaves of hollies having similar crown areas and ages.

Summary of Growth Results

The results of the growth study have shown that height, crown area, and number of leaves of holly in the older age classes investigated are all reduced in amount by shade from a canopy. Table 1 shows the extent of these reductions in 16-year-old hollies.

Table 1

Comparison of Three Hypothetical 16-Year-Old Hollies Growing under Three Different Conditions of Sunlight

Sunlight Classes	Height		Crown Area		Leaves	
	Feet	%	Sq. Ft.	%	Number	%
Full sunlight	7.3	100	61.5	100	1900	100
Medium shade	6.2	85	41.0	67	600	32
Heavy shade	5.3	73	26.5	43	300	16

These data represent three hypothetical 16-year-old trees based on average values for trees of that age as read from curves of the foregoing figures. The heights were taken from Figure 1, and the crown areas from Figure 2. The number of leaves was taken from Figure 4, using the appropriate crown area for each sunlight class as indicated in the table under the column labeled "Crown Area".

The action of shade from a canopy has been found to reduce both the number of leaves in equal crown areas, and the crown areas of trees the same age. Therefore, on the basis of the previous presentation of the growth factors, a double reduction results. The size of the crown is reduced by the shade; and as the size of the crown is reduced, the density of the foliage also is reduced.

In order to show the relative reduction in the size of each of the three growth factors by shade, full sunlight has been taken as 100 per cent, and the values in the shade are expressed as a percentage of the full sunlight value.

The percentage values in Table 1 indicate that the heavy shade class reduces height growth of the 16-year-old holly to 73 per cent, crown area to 43 per cent, and the number of leaves to 16 per cent as compared with values for open grown holly. Thus the most important factor in the production of material for holly greens, the number of leaves, through reduction in both crown size and density, shows the greatest reduction.

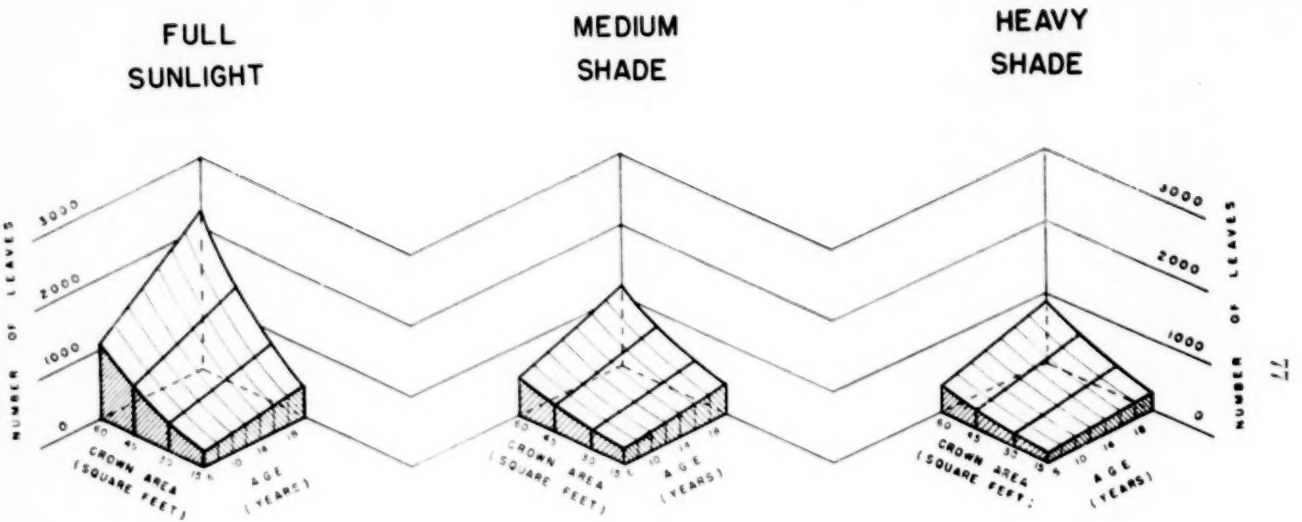

Figure 4. Influence of crown area and age on number of leaves occurring on holly trees growing in the open and in the shade of natural canopies.

Full sunlight: trees receiving 100% sunlight
Medium shade: trees receiving 21%-80% sunlight
Heavy shade: trees receiving less than 21% sunlight

Three holly trees, one growing in the open, and two under canopies of different densities, are shown in Figure 5. These hollies were growing under conditions which include the extremes of sunlight received by trees studied and illustrate the reduction in number of leaves by the shade. Their measurements are presented in Table 2.

Table 2

Data on the Three Hollies in Figure 5

Measurement	Holly		
	A	B	C
Total height (feet)	5.5	5.7	4.7
Crown length (feet)	5.4	5.6	1.8
Crown width (feet)	3.2	3.0	1.1
Number of leaves	2450	800	75
Age (years)	9	17	21
Sunlight (per cent)	100	40	1

Holly A was growing in the open on an old field having a fair site quality. Holly B was growing in the same field under a canopy of dwarf sumac (*Rhus copallina* L.) Holly C was growing nearby on a better site, but under a dense canopy of eastern hemlock (*Tsuga canadensis* (L.) Carr.).

Leaf Characteristics

The effect of shade from a canopy on certain holly leaf characteristics was studied. Characteristics were chosen for study which would be important in selling holly foliage. They were length of leaves, lustre, and color.

Length of Leaf

The length of leaves was chosen to indicate size. Leaf length of holly growing under canopies of different densities was compared with that of holly growing in the open. The hollies growing under the canopies were divided into eleven sunlight classes based on the percentage of sunlight received by the trees. The average length of the leaves in each sunlight class was compared to that of the open grown holly (100% class) by the *t*-test which indicates the significance of the difference between the two means. The results are presented in Table 3. This table shows that the leaves are actually longer after

Figure 5. Appearance of holly growing in the open and under canopies of two different densities.

A. 100% sunlight
9 years old

B. 40% sunlight
17 years old

C. 1% sunlight
21 years old

Table 3

Effect of Shading by a Canopy on Length and Lustre of Holly Leaves

Sunlight class (per cent)	Length		Lustre		Color	
	Length of leaves (inches)	Significance of difference of shaded classes with open grown holly	Lustre of leaves (relative)[6]	Significance of difference of shaded classes with open grown holly	Relative amount of green[5]	Significance of difference of shaded classes with open grown holly
100	2.04		2.03		1.02	
81-90					1.00	None
71-80	1.98	None	2.29	None	1.00	None
61-70	2.11	None	2.20	None	1.00	None
51-60	2.07	None	2.50	Sig.[8]	1.09	None
41-50	2.22	Highly Sig.[7]	2.43	Sig.	1.04	None
31-40	2.22	Highly Sig.	2.09	None	1.07	None
21-30	2.39	Highly Sig.	2.29	None	1.11	None
11-20	2.40	Highly Sig.	2.69	Highly Sig.	1.23	Highly Sig.
6-10	2.47	Highly Sig.	2.91	Highly Sig.	1.36	Highly Sig.
3-5	2.47	Highly Sig.	2.78	Highly Sig.	1.21	Sig.
0-2	2.50	Highly Sig.	3.12	Highly Sig.	1.57	Highly Sig.

[5]Larger numbers signify a high proportion of green to yellow, and consequenlty more desirable color.
[6]The higher the value the greater the lustre of the leaves.
[7]Highly Sig. means significant at the 1% level.
[8]Sig. means significant at the 5% level.

the percentage of sunlight is reduced below 50 per cent; and that as the percentage of sunlight is reduced further, the leaves become relatively longer.

Lustre of Leaf

The lustre of leaves of holly growing under canopies of different densities was compared with the lustre of the leaves of open grown holly. This comparison is given in Table 3.

The degree of lustre is represented by number. The lustre classification descended from 4, the highest class, through 3 and 2, to 1. Hence, the larger the number the more lustrous is the leaf.

The leaves of hollies receiving less than 20 per cent sunlight are more lustrous than leaves of open grown holly, as shown by highly significant differences, and the leaves of holly in the deepest shade are the most lustrous.

Color of Leaf

The effect of shade from a canopy on the color of holly leaves was studied previously and has been reported.[9] The relative darkness of the leaves and amount of green in relation to amount of yellow were investigated. Shading has no effect on the relative darkness of the leaves; however, the relative amount of green in the holly leaves is affected by shading as indicated in Table 3. The relative amount of green was classified by number, with the value 3 representing the greatest amount, 2 an average amount, and 1 the least. Therefore, the higher the number the more green in relation to yellow, and the more desirable the leaf color. This table shows that differences in amount of green between open and shade grown leaves do not vary significantly until the amount of sunlight has been reduced to 20 per cent. At this point and below the majority of the classes differ in a highly significant manner from open grown holly. The leaves containing the most green are in the deepest shade. Therefore, under natural conditions, leaves having the most desirable color are produced under low sunlight intensities. It is of interest that at light intensities below 20 per cent both color and lustre of leaves are improved, as shown by highly significant differences.

[9]Tryon, E. H. Color Comparison of Leaves of Open and Shade Grown Holly. Castanea 15: 117-126. 1949.

CONCLUSIONS

This investigation has shown that shade from a canopy affects both quantity and quality of holly foliage. Growth of holly as measured by height, crown area, and number of leaves is reduced by shade, with number of leaves showing the greatest reduction. Sixteen-year-old trees growing in medium and heavy shade, had 32 and 16 per cent as many leaves, respectively, as trees the same age growing in the open. The number of leaves produced on hollies is important because foliage is one of the chief factors determining the value of a holly tree for the production of cut sprays. Therefore, holly grown in the open is superior from the standpoint of growth.

The quality of the foliage, however, was found to be improved by shade from a canopy, and particularly by heavy shade. Leaves on holly growing under heavy shade were longer, more lustrous, and more desirable in color than those on open-grown holly. When sunlight is reduced below 59 per cent, the leaves are longer, but lustre and color are not improved until sunlight is reduced below 20 per cent.

From the standpoint of the holly grower, the results of this study must seem confusing if he is to apply them in his production work, because shade from a canopy improves the quality of the leaves while reducing the amount of foliage. However, a careful examination of the results will clarify this apparent inconsistency. The two most important leaf characteristics studied—color and lustre—are improved only when the amount of sunlight is reduced below 20 per cent. However, under this low percentage of sunlight the growth of holly, particularly the amount of foliage, is so low that production of sprays would be impracticable.

Also there are indications that the poorer leaf characteristics found on open grown holly may be improved by proper cultural practices. Observations of holly trees growing in fields where fertilizer had been added for the production of other crops indicate that the quality of holly leaves may be improved by fertilization. At West Virginia University investigations have recently been started in the Agricultural Experiment Station attempting to discover methods for improving the quality of holly foliage.

Female hollies growing in the shade have been observed to produce fewer berries than open grown trees. This is of particular importance in the production of sprays having natural berries.

All factors studied, and those observed indicate the desirability of growing holly in the open.

ACKNOWLEDGMENTS

The authors appreciate the cooperation of Morris and Ira McClung of Nicholas County, and of George Brady and Raymond Irvin of Upshur County, for allowing the use of their lands for this study. The late William Legg of Mt. Lookout assisted in locating the plots. Mr. V. O. Havener of the West Virginia Agricultural Experiment Station helped in analyzing the data. Clifford Myers, Assistant Professor of Forestry, helped with the field work. Robert King, Earl Smith, and Charles Roberts, formerly students in the Division of Forestry assisted with many phases of the work.

Dr. Walter D. Foster, Associate Statistician for the Experimental Station, determined the methods for statistical treatment of the data.

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Plants of Cleft Island, Maryland

W. L. McAtee

A description of this island and of its hazards for vegetation may be found in Nature Magazine (45:321-323, 1952); and a photograph showing its barren nature and its relation to the Great Falls of the Potomac was published in The Living Wilderness (9:28, lower right foreground, 1944). Cleft Island is so named from the four gashes traversing it in line with its stratification. It is exposed to the full force of the River, collected again after tumbling over the Falls; is partially covered by flood waters every year; and is entirely submerged by great freshets, as those of 1889 and 1936.

It is thus periodically denuded of soil, except in protected situations, but is supplied again with soil and seed, settling from the falling waters. Some of the plants are highly transitory, including waif crop plants and weeds, which occur mostly on scanty deposits of mud and sand at a few favorable nooks along the shore. The more permanent occupants are anchored in rock crevices or find a haven in elevated soil pockets, as in ancient potholes, which probably are never entirely scoured out. Notable absentees are the common "spring flowers" of deciduous woodland of the region, as: *Erythronium, Anemonella, Hepatica, Sanguisorba, Dentaria,* and a dozen others. These are humus lovers, which find no home on this rocky isle.

The dominant plants are: *Pinus virginiana, Juniperus virginiana,* three species of *Quercus,* two of *Andropogon, Sorghastrum nutans, Lespedeza capitata, Diospyros virginiana, Campsis radicans,* and, on rocky terraces, mosses. (This paper takes no further notice of the lower plants.) Characteristics rock-crevice inhabitants include: *Andropogon scoparius, Aquilegia canadensis, Arabidopsis thaliana, Heuchera americana, Physocarpus opulifolius, Amelanchier canadensis, Euphorbia corollata, Parthenocissus quinquefolia, Hypericum spathulatum, Oenothera biennis, Vaccinium vacillans, Phlox subulata, Pycnanthemum flexuosum, Solidago racemosa, Aster patens, Aster linariifolius,* and *Senecio pauperculus.* Water pockets afford habitat for a variety of species, which would not otherwise be found. One of them, large enough to be called a tarn, at an elevation of about forty feet above low-water in the River, seems like a hanging garden with its yellow and white waterlilies, and the bordering rose mallow and royal fern. It seemed especially odd to see in this still water such a current-frequenting plant as the water-willow (*Justicia*).

The flora of Cleft Island differed from year to year; indeed, one could well say, from month to month. It was anything but a fixed quantity. The following list of 236 (plus 6 unidentified) species of fern-allies and seed-plants resulted from five principal visits in fall and winter, 1917 to 1919; and two in March and April, 1930, a very dry year, and the only one in which I was able to get on the Island in spring.

Nomenclature has been made to conform largely with that of Gray's Manual of Botany (8th ed. 1950, M. L. Fernald). I have used Rhododendron as including Azalea, under protest, but I am quite unable to accept the sinking of Chamaecrista and Steironema. Notes on seasons of flower and fruit have been included when additional to data presented in "Flora of the District of Columbia and Vicinity" (Contrib. U.S. Nat. Herb., 21, 1919).

It is pretty certain that all difficult grasses were named by Mrs. Agnes Chase. Dr. S. F. Blake aided similarly in his specialty, the Compositae, and also with several other knotty points. These friends have always been helpful and I am correspondingly grateful.

PTERIDOPHYTA. Ferns and fern allies

EQUISETACEAE

Equisetum arvense L. On mud north shore.

OSMUNDACEAE

Osmunda regalis L. A few plants near waterhole, west end.

POLYPODIACEAE

Woodsia obtusa (Spreng.) Torr. A few clumps on cliff with north exposure, west end.

Dryopteris marginalis (L.) Gray. A single clump, in a cavern among rocks, west end.

Polystichum acrostichoides (Michx.) Schott. Several colonies in soil pockets on higher parts of main island, scattered elsewhere.

Asplenium trichomanes (L.) Oakes. A few fronds on cliff, north exposure.

Asplenium platyneuron L. Scattered in rock crevices over whole island, but not plentiful.

PINACEAE

Pinus virginiana Mill. Common in soil pockets; a few stunted specimens in rock cracks.

Juniperus virginiana L. Common; tolerates less soil than the pine; fruit is on the trees at all seasons.

ZOSTERACEAE

Potamogeton zosteriformis Fern. Common in pool, west cleft; seen also in pothole, top of main island.

NAJADACEAE

Najas flexilis (Willd.) Rostk. and Schmidt. Pool, west end.

ALISMATACEAE

Alisma subcordatum Raf. Shore of pool, west cleft; a fruiting stalk 4½ feet high was seen; fruit September to November.

Sagittaria latifolia Willd. Pool, west cleft.

HYDROCHARITACEAE

Elodea canadensis Michx. Pool, west cleft.

GRAMINEAE

Eragrostis hypnoides (Lam.) BSP. Pool among rocks, west end; fruit present October.

Triodia flava (L) Smyth. Soil pocket, top of main island.

Elymus virginicus L. A few plants in rock crevices, west end.

Elymus canadensis L. One colony, west cleft.

Agrostis hyemalis (Walt.) BSP. Near pool, west cleft; fruit present September 21.

Muhlenbergia schreberi J. F. Gmelin. Near pool, west cleft; fruit fallen in November.

Aristida purpurascens Poir. Numerous in clefts; fruit in October and November.

Gymnopogon ambiguus (Michx.) BSP. Big soil pocket; fruit mostly fallen, October 5.

Leersia virginica Willd. Pool among rocks, west end.

Digitaria ischaemum (Schreb.) Muhl. In rock crevices; fruit fallen, November.

Panicum dichotomiflorum Michx. Among rocks, north shore.

Panicum gattingeri Nash. Among rocks, north shore; fruit of this and preceding present, October.

Panicum virgatum L. In soil pockets, top of main island.

Panicum dichotomum L. In rock crevices, top of main island; fruit present in November.

Panicum lanuginosum Ell. var. fasciculatum (Torr.) Fern. Scattered in rock crevices; a little fruit present in November.

Panicum polyanthes Schultes. North exposure of main island; fruit in November.

Panicum commutatum Schultes var. ashei (Pearson) Fern. Scattered in rock crevices; fruit fallen in November.

PANICUM CLANDESTINUM L. Common in large soil pocket, top of main island; also on mud, north shore; fruit present in November.

ECHINOCHIOA CRUS-GALLI L. On sand among low rocks, north side; fruit present in November.

SETARIA GLAUCA (L.) Scattered, in rock crevices and in sand; fruit fallen in November.

SETARIA VIRIDIS L. West end.

ANDROPOGON SCOPARIUS Michx. In rock crevices everywhere, scattered in other situations also; one of the most conspicuous plants; fruit in October and November.

ANDROPOGON GERARDI Vitman. North slope, main island; fruit in October.

SORGASTRUM NUTANS (L.) Nash. Common in clefts and on main island; its brown stalks the dominant feature of the clefts in fall and winter; fruit present in November.

TRIPSACUM DACTYLOIDES L.—Common on soil pockets, east cleft and main body of island.

CYPERACEAE

CYPERUS ODORATUS L. Near waterhole; on sand north shore; and among rocks there in the edge of the river; flowers and fruit present, September 21.

ELEOCHARIS ACICULARIS L. Large colony in mud north shore.

ELEOCHARIS OBTUSA (Willd.) Schultes. Pool among rocks, west end; fruit present October 5.

SCIRPUS AMERICANUS Pers. A colony on mud, north shore.

SCIRPUS RUBRICOSUS Fern. About water pockets; fruit mostly fallen in November.

RHYNCHOSPORA GLOMERATA (L.) Vahl. Shore of pool, west cleft, and about waterholes elsewhere; fruit present November.

CAREX PENSYLVANICA Lam. Rock crevices; in flower April 27, 1930.

ARACEAE

ACORUS CALAMUS L. Shore of large waterhole.

JUNCACEAE

JUNCUS BUFONIS L. Pool among rocks, west end; fruit present October 5.

JUNCTUS DUDLEYI Wieg. Scarce about waterholes; fruit present November, as also on the following two species.

JUNCUS EFFUSUS L. var. SOLUTUS Fern. and Wieg. A few colonies, about waterholes.

JUNCUS ACUMINATUS Michx. Fringing a number of the larger waterholes.

LILIACEAE

Allium cernuum Roth. Scattered in rock crevices and common in soil pockets; capsules empty, November.

Smilacina racemosa (L.) Desf. Large soil pocket on top of island.

Polygonatum biflorum (Walt.) Ell. Same as last.

Smilax pulverulenta Michx. Moist soil pocket near top of main island; fruit present, November.

Smilax rotundifolia L. Scattered in sand in clefts and in soil pockets elsewhere.

Smilax tamnoides var. hispida (Muhl.) Fern. East cleft.

Smilax glauca Walt. Common in soil pockets.

ORCHIDACEAE

Spiranthes cernua (L.) Richard. Near water pocket, west end: in flower October 15, 1919.

SALICACEAE

Salix nigra Marsh. Scattered in crevices near river.

Salix caroliniana Michx. Several bushes along north and west shores.

Populus deltoides Marsh. Scattered in crevices and among boulders near river.

JUGLANDACEAE

Carya cordiformis (Wang.) K. Koch. In soil pockets, fairly numerous.

Carya ovalis (Wang.) Sarg. Numerous in soil pockets on higher parts of island.

CORYLACEAE

Ostrya virginiana (Mill.) K. Koch. Not common.

Betula nigra L. Scattered in crevices near river.

Alnus rugosa (Du Roi) Spreng. Scattered near waterholes, and in wet soil, north exposure.

FAGACEAE

Quercus stellata Wang. Common in soil pockets; acorns present, November.

Quercus prinus L. A few in soil pockets.

Quercus velutina Lam. Common in soil pockets.

ULMACEAE

Ulmus americana L. A few small trees near pool, west cleft.

Celtis sp. A number of small hackberries, in soil pockets.

URTICACEAE

Boehmeria cylindrica (L.) Sw. Near pool, west cleft; fruit on plants only 3 inches high in November.

POLYGONACEAE

Rumex crispus L. On sand, north shore; fruit present, November.

Rumex obtusifolius L. Among rocks near river, southwest corner.

Polygonum pensylvanicum L. Among low rocks, north side.

Polygonum lapathifolium L. Common among rocks along shore, and in sand; mostly without fruit in November.

Polygonum persicaria L. In sand north shore; flowers to mature fruit present in November.

Polygonum punctatum L. Near pool west cleft; some of the plants exemplify the variety eciliatum Small; flowers to mature fruit present, September 21; fruit in November also.

AMARANTHACEAE

Amaranthus graecizans L. Among rocks near river southwest corner; fruit present in November.

AIZOACEAE

Mollugo verticillata L. A few mats on sand, north shore.

PORTULACACEAE

Portulaca oleracea L. On sand, north end.

CARYOPHYLLACEAE

Stellaria pubera Michx. Occasional, spring.

Saponaria officinalis L. Common in sand, especially in west cleft; but present elsewhere and on other soils; fruit fallen in November.

NYMPHAEACEAE

Nuphar advena (Ait.) Ait. f. Pool, west cleft.

Nymphaea odorata Ait. Plentiful in pool, west cleft; some leaves 18 inches in diameter.

RANUNCULACEAE

Ranunculus sceleratus L. On mud, north shore.

Anemone virginiana L. Near pool, west cleft.

Anemone quinquefolia L. One colony seen on bank of soil at foot of a north facing rock wall, in company with *Kalmia latifolia;* this same association observed on Plummers Island, Md., 4 miles downstream.

Clematis virginiana L. A number of plants on main island.

AQUILEGIA CANADENSIS L. In rock crevices everywhere; common on the most exposed cliffs; new leaves, March 30; empty capsules in November.

MAGNOLIACEAE

LIRIODENDRON TULIPIFERA L. One tree near pool, west cleft; fruit present in November.

LAURACEAE

SASSAFRAS ALBIDUM (Nutt.) Nees. One small tree observed on high northwestern part of main island; fruit present in November.

CRUCIFERAE

LEPIDIUM VIRGINICUM L. On sand, north shore; flowers April 27; fruit still present in November.

ARABIDOPSIS THALIANA (L.) Heynh. Common in rock crevices.

RORIPPA SYLVESTRIS (L.) Bess. Among rocks near river, west end.

BARBAREA VULGARIS R. Brown. On sand, north shore.

CARDAMINE PENNSYLVANICA Muhl. Margin of pool, west cleft.

SAXIFRAGACEAE

PENTHORUM SEDOIDES L. A few plants near pool, west cleft; fruit present in November.

SAXIFRAGA VIRGINIENSIS Michx. Not common.

HEUCHERA AMERICANA L. Common in rock crevices.

PLATANACEAE

PLATANUS OCCIDENTALIS L. Small trees among rocks here and there near river; a few larger ones on the most protected shore had been battered by ice.

ROSACEAE

PHYSOCARPUS OPULIFOLIUS (L.) Maxim. Scattered in rock crevices; most common on north side; fruit present in November.

AMELANCHIER STOLONIFERA Wieg. Occasional; in flower, March 30 and April 27.

AMELANCHIER CANADENSIS (L.) Medic. Scattered over whole island, in rock crevices.

CRATAEGUS UNIFLORA Muenchh. Numerous in soil pockets; a specimen only 18 inches high was full of fruit, October 5.

CRATAEGUS CRUS-GALLI L. West cleft; abundant fruit, September 21.

FRAGARIA VIRGINIANA *Duchesne*. On mud, north shore.

POTENTILLA CANADENSIS L. Common, east cleft and north shore.

GEUM CANADENSE Jacquin. Near pond, west cleft.

RUBUS 2 spp., not identified.

Rosa virginiana (Mill.) Scattered, both on sand and in rock crevices; fruit present, November.

LEGUMINOSAE

Cassia marilandica L. In sand, north shore; also near pool, west cleft; fruit present in November.

Chamaecrista fasciculata (Michx.) Greene. Among rocks, south end.

Cercis canadensis L. Occasional; buds opening March 30.

Baptisia australis (L.) R. Br. Common in sand in clefts and other low places, especially on north slope.

Trifolium pratense L. A few plants among rocks, river's edge, west end.

Trifolium repens L. On mud, north shore.

Melilotus alba Desr. One plant in large pothole, east cleft; flowers to fruit present in November.

Robinia pseudo-acacia L. Common in soil pockets; fruit present in November, a remark applying also to the next three entries.

Desmodium glutinosum (Muhl.) Wood. Near pool, west cleft.

Lespedeza virginica (L.) Britt. Scattered in rock crevices.

Lespedeza capitata Michx. Scattered on higher parts of main island and common on middle northern slope; persistent through the winter.

Vicia caroliniana Walt. In soil pockets.

Lathyrus venosus Muhl. Most common on sand in clefts, but scattered elsewhere.

Galactia regularis (L.) BSP. Rock crevices.

Galactia vilubilis (L.) Britt. In east cleft and in cedar pothole; fruit present, September 21.

OXALIDACEAE

Oxalis europaea Jord. forma cymosa Small. Among rocks, north shore; fruit present, September 21.

Oxalis grandis Small. Scattered in potholes and rock crevices, and on sand; fruit present in November.

EUPHORBIACEAE

Acalypha virginica L. Scattered in various situations from rock crevices to mud on shore; flowers to fruit present in November.

Euphorbia corollata L. Common in rock crevices; some flowers persisting, almost dry, coriaceous, in November.

Euphorbia maculata L. Scattered in various situations; a plant only 2 inches high bore mature fruit in November.

CALLITRICHACEAE

Callitriche palustris L. Common in pool, west cleft, also on muddy shore of same.

ANACARDIACEAE

Rhus copallina L. Common on higher parts of island.

Rhus toxicodendron L. Common, both in rock crevices and in soil pockets.

AQUIFOLIACEAE

Ilex decidua Walt. Common in sand of clefts, and in soil pockets on high parts of island; in the latter situation the plant assumes an unusual appearance; probably because of poor nutrition. The spurs on which fruit are borne are stubby and closely covered with scars evidently of many years growth; the fruit (seen September to November) is smaller than the average for this species, and is borne on long peduncles at the tips of the spurs, some of the peduncles (10-15 mm.) being twice as long as the diameter of the fruit. Examination of material classed as *I. decidua* during the study of this plant leads me to believe this group requires further segregation.

Ilex verticillata L. One bush among rocks, north exposure, and one in west cleft; fruit seen in same months as that of the last species.

CELASTRACEAE

Euonymus americanus L. Scattered on main island.

ACERACEAE

Acer rubrum L. Common; found in almost all parts of the island where plants have a foothold; half grown fruit, April 27.

BALSAMINACEAE

Impatiens capensis Meerb. One plant on cliff, west end.

VITACEAE

Parthenocissus quinquefolia (L.) Planch. Common in both rock crevices and soil pockets; fruit present in November.

Vitis vulpina L. Fairly common; some plants in situations covered by water most of year.

Vitis rupestris Scheele. East cleft.

TILIACEAE

Tilia americana L. A few small trees near pool, west cleft.

MALVACEAE

Sida spinosa L. In mud and sand, north shore; fruit present, November.

HIBISCUS MILITARIS Cav. One plant in pool, west cleft.

HYPERICACEAE

HYPERICUM SPATHULATUM (Spach.) Steud. Common in rock crevices, and elsewhere; fruit present, November.

HYPERICUM MUTILUM L. On mud, near pool, west cleft; and among rocks, west end.

VIOLACEAE

VIOLA PAPILIONACEA Pursh. On sand, north shore.

VIOLA SORORIA Willd. Among rocks near river, west end.

VIOLA SAGITTATA Aiton. North slope, main island.

PASSIFLORACEAE

PASSIFLORA LUTEA L. Big pothole.

CACTACEAE

OPUNTIA HUMIFUSA Raf. Common in a large soil pocket on a high part of main island; fruit present, November.

LYTHRACEAE

CUPHEA PETIOLATA (L.) Koehne. In large pothole, east cleft; and on sand among rocks north shore; fruit present in November.

NYSSACEAE

NYSSA SYLVATICA Marsh. Several small trees on northwestern part of main island.

ONAGRACEAE

LUDWIGIA ALTERNIFOLIA L. In rock crevices, particularly about water holes; mature capsules on bare stems in November.

LUDWIGIA PALUSTRIS (L.) var. AMERICANA (DC.) Fern. and Grisc. In a water pocket, northwest part of main island, and abundant in pool, also on muddy edge thereof, west cleft.

EPILOBIUM COLORATUM Biehler. In mud, north shore; and among rocks, west end; flowers, September 21; fruit, November.

OENOTHERA BIENNIS L. Scattered in rock crevices; fruit persists through the winter.

UMBELLIFERAE

ZIZIA AUREA (L.) W.D.J. Koch. Basal leaves only, seen on island; in flower on main shore nearby, November 16.

DAUCUS CAROTA L. A few plants, west cleft.

CORNACEAE

CORNUS FLORIDA L. Common in soil pockets; both white and pink flowers, April 27, 1930.

CORNUS AMOMUM Mill. About pool, west cleft.

ERICACEAE

RHODODENDRON NUDIFLORUM (L.) Torr. Several clumps on western end of main island.

KALMIA LATIFOLIA L. Scattered in soil pockets, seeming to prefer the north side of rock walls.

LEUCOTHOE RACEMOSA (L.) Gray. Scattered on higher parts of main island, in rock crevices and about water holes; mature fruit and last year's empty capsules present in November.

VACCINIUM VACILLANS Torr. Common in rock crevices; red leaves present on many plants, some fruit still hanging in semi-pulpy condition, November 24, 1918.

VACCINIUM ANGUSTIFOLIUM Ait. var. LAEVIFOLIUM House. Common in rock crevices; all leaves fallen by mid-November.

PRIMULACEAE

STEIRONEMA CILIATUM (L.) Raf. One colony in large pocket of moist soil, top of main island; capsules empty in November as also in the next two species.

STEIRONEMA QUADRIFLORUM (Sims.) Hitchc. A few colonies, west cleft.

ANAGALLIS ARVENSIS L. East cleft.

EBENACEAE

DIOSPYROS VIRGINIANA L. Common and well distributed.

OLEACEAE

FRAXINUS AMERICANA L. Common in soil pockets on higher parts of island; fruit mostly fallen in November.

CHIONANTHUS VIRGINICA L. Common on higher parts of main island.

APOCYNACEAE

APOCYNUM sp. A few plants in fruit; north shore main island, and in west cleft (November).

ASCLEPIADACEAE

ASCLEPIAS INCARNATA L. A few plants along shore, north side; fruit present in November.

CONVOLVULACEAE

IPOMOEA HEDERACEA (L.) Jacq. Single-stalked plants, a few inches high in large potholes, east cleft; nevertheless, in fruit, November; this remark applies also to the next species.

IPOMOEA LACUNOSA. L. On sand in east cleft and on north shore.

CONVOLVOLUS SEPIUM L. Climbing on bushes, west cleft.

CUSCUTA GRONOVII Willd. West cleft, growing vigorously upon trumpet-creeper; fruit in November.

POLEMONIACEAE

PHLOX SUBULATA *L.* Abundant in rock crevices; flowers of April 27, 1930, were fragrant.

BORAGINACEAE

ECHIUM VULGARE L. A single plant, west cleft.

LITHOSPERMUM LATIFOLIUM Michx. On high part of main island, most numerous in soil pockets; fruit present in November.

LABIATAE

SCUTELLARIA LATERIFLORA L. At base of west cliff; fruit in November.

GLECHOMA HEDERACEA L. Shore of pool, west cleft.

PRUNELLA VULGARIS L. One colony in a low crevice, near north shore.

PHYSOSTEGIA VIRGINIANA L. Several colonies in rock crevices and on sand in clefts and near shore; capsules empty in November.

PYCNANTHEMUM FLEXUOSUM (Walt.) BSP. Colonies common in rock crevices.

LYCOPUS RUBELLUS Moench. Near pool, west cleft; and among low rocks, north side.

MENTHA ARVENSIS L. var. VILLOSA (Benth.) S. R. Stewart. On mud, north shore; fruit in November.

SOLANACEAE

SOLANUM CAROLINENSE L. East cleft.

LYCOPERSICON ESCULENTUM Mill. On sand and among rocks along shore; one plant with a green fruit 4 inches in diameter in November.

DATURA STRAMONIUM L. In sand, east cleft and north shore; fruit in November.

SCROPHULARIACEAE

VERBASCUM THAPSUS L. One small rosette of basal leaves on sand, north shore.

PENTSTEMON HIRSUTUS (L.) Willd. North cliff.

VERONICASTRUM VIRGINICUM (L.) Farw. In colonies on middle northern slope; scattered in crevices elsewhere; fruit in November.

BIGNONIACEAE

CAMPSIS RADICANS (L.) Seem. Common, clambering over rocks from footholds of both scanty and plentiful soil; fruit present in November.

ACANTHACEAE

JUSTICIA AMERICANA (L.) Vahl. A large colony along north shore; a little at other points among marginal rocks; and at pool.

PLANTAGINACEAE

PLANTAGO MAJOR L. On mud, north shore.

PLANTAGO LANCEOLATA L. On sand, north shore.

RUBIACEAE

GALIUM PILOSUM Ait. Scattered in soil pockets; a little fruit left in November, as in all the species of the family.

DIODIA TERES Walt. On sand, and among low rocks, north shore.

MITCHELLA REPENS L. In rock crevices on north exposure, and in mossy ground on highest parts of island.

CEPHALANTHUS OCCIDENTALIS L. About water pockets.

HOUSTONIA LONGIFOLIA Gaertn. Scattered in rock crevices, everywhere.

CAPRIFOLIACEAE

VIBURNUM PRUNIFOLIUM L. Common in rock pockets where considerable soil has accumulated; this and the following had fruit in November.

VIBURNUM AFFINE Schneider. Common on higher parts of the main island; both the nominate variety and var. HYPOMALACUM Blake occur, the latter dominant.

VIBURNUM "DENTATUM L". One or more species of the *dentatum* group occur in the clefts and about water holes, but in the absence of material, cannot safely be named at this date.

CUCURBITACEAE

CUCURBITA PEPO L. One plant among rocks near river, southwest corner.

CAMPANULACEAE

CAMPANULA AMERICANA L. Near pool, west cleft.

COMPOSITAE

EUPATORIUM PURPUREUM L. A few plants near pool, west cleft.

EUPATORIUM HYSSOPIFOLIUM L. var. LACINIATUM Gray. Common in soil pockets and rock crevices; fruit present in November.

EUPATORIUM PERFOLIATUM L. A few plants near pool, west cleft.

EUPATORIUM COELESTINUM L. North exposure, main island.

SOLIDAGO BICOLOR L. In rock crevices and soil pockets, but less common than *S. racemosa;* a few flowers left and much fruit in November.

SOLIDAGO RACEMOSA Greene. Abundant in rock crevices over whole island; flowers to fruit in November.

SOLIDAGO GIGANTEA Ait. var. LEIOPHYLLA Fern. A few plants in west cleft and on north exposure of main island.

ASTER PATENS Ait. Common in rock crevices; scattered everywhere; flowers to the end of November as well as fruit.

ASTER ERICOIDES L. A few colonies in sheltered soil pockets; flowers to fruit in November.

ASTER LATERIFLORUS (L.) Britt. Among rocks, southwest corner; flowers to fruit, October 5.

ASTER SIMPLEX Willd. var. RAMOSISSIMUS (T. & G.) Cronq. One plant among rocks, near river, southwest corner; fruit in November.

ASTER LINARIIFOLIUS L. Abundant; this species probably lives in the most unfavorable situations of any of the vascular plants, a mere crack in the most exposed rock sufficing for it. Plants only two inches high produce flowers and fruit, September to November.

ERIGERON ANNUS (L.) Pers. On sand, north shore.

ANTENNARIA PLANTAGINIFOLIA (L.) Hook. Soil pockets, higher parts of island, and crevices, west end.

ANAPHALIS MARGARITACEA (L.) C. B. Clarke. Scattered over higher parts of main island.

GNAPHALIUM OBTUSIFOLIUM L. Soil pocket, top of island.

AMBROSIA ARTEMISIIFOLIA L. A few plants in sand in the clefts and on mud and among low rocks, north shore.

XANTHIUM CHINENSE Mill. Among low rocks, north side; fruit September 21.

XANTHIUM ITALICUM Moretti. In sand, east cleft; fruit, November.

SILPHIUM TRIFOLIATUM L. Old stalks with mature fruit, west cleft, November.

HELIANTHUS OCCIDENTALIS Riddell. Colonies in sand, east cleft, and in rock crevices elsewhere.

HELIANTHUS DIVARICATUS L. Colonies in east cleft, and on main island; fruit present in November.

COREOPSIS TRIPTERIS L. Scattered on main island.

BIDENS CERNUA L. On mud, north shore; fruit of this and next in November.

BIDENS FRONDOSA L. In sand, north shore and west cleft.

ACHILLEA MILLEFOLIUM L. East cleft.

ERECHTITES HIERACIFOLIA (L.) Raf. Scattered about island in various situations, from mud to rock cracks; fruit present in November.

CACALIA SUAVEOLENS L. One plant near pool, west cleft; another on mud, north shore.

SENECIO PAUPERCULUS Michx. Abundant in crevices, all over island.

TARAXACUM OFFICINALE Webet. On sand, north shore.

LACTUCA BIENNIS (Moench.) Fern. Near pond west cleft.

HIERACIUM sp .Basal leaves, west cleft.

CHAPEL HILL, N.C.

BOOK REVIEW

Note:

This footnote concerning "Herbs in My Garden" was inadvertently omitted on p. 68 of the June issue.

*The years in my Herb Garden. Helen M. Fox. 185 pp. $3.95. The Macmillan Company. New York. 1953.

PLANTS OF THE BIBLE.*—A book of great interest to plant lovers everywhere is *Plants of the Bible,* published recently by Dr. and Mrs. Moldenke, the latest in a long series of books and papers dealing with that popular subject. References are made to 605 previously published works, so that it may be considered that the present authors have had the advantage of the exhaustive discussions that have been in progress for hundreds of years, and in many lands.

The authors attempt to account for all plants mentioned in the Bible. It is, of course, apparent that not all plants of the Bible can be identified with certainty today, but the Moldenkes present 230 species, in alphabetical order from *Acacia nilotica* (L.) Forsk. to *Zostera marina* L., which they feel may be identified with a reasonable degree of accuracy, and some dozens of others about which there is no certainty. In the treatments of each species, quotations are made from various parts of the Bible in which the names of the plants occur. Some of these involve long lists, as, for example, the common fig, which is mentioned at least 57 times. Following these citations there are lengthy discussions, drawing upon the voluminous literature to reach the conclusions attained by the authors. The entire Bible, including the 14 books of the Old Testament Apocrypha, is covered by the citations. Most of the quotations are from the well-known "King James Version", but reference is made to other versions as well,

*Plants of the Bible. Harold N. Moldenke and Alma L. Moldenke. 328 p. 95 fig. $7.50. Chronica Botanica Co., Waltham, Mass. 1952.

including the "Moffatt Version", the "Weymouth Version", the "Goodspeed Version", the "Revised Standard Version", the "Catholic Bible" or "Douay Version", and the Jewish works known as the "Jestrow Version" and the "Leesser Version".

The illustrations include reproductions of various old wood engravings, several photographs of present-day vegetational conditions in Palestine, and numerous original vignettes and tailpieces.

The high degree of scholarship exemplified is indicated not only by the comprehensive bibliographic treatment, but also by the very exhaustive general index, including some 5000 items.

A word of commendation should be given for Dr. Franz Verdoorn, editor of the Chronica Botanica series, for having added another to his already long list of valuable plant science publications—EARL L. CORE.

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